KIRKALDY'S EXPERIMENTAL INQUIR

INTO THE PROPERTIES OF

ESSEN AND YORKSHIRE WROUGHT-IRON

RESULTS

OF

AN EXPERIMENTAL INQUI

INTO THE

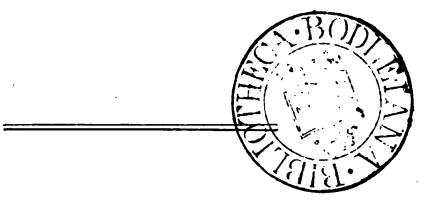
RELATIVE PROPERTIES OF WROUGHT-IR

MANUFACTURED AT

ESSEN, RHENISH PRUSSIA, AND YORKSHIRE, EN

BY

DAVID KIRKALDY.



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PRELIMINARY REMARKS.

HAVING been informed that it was desired to ascertain, by mea experiments, the relative merits of Wrought-Iron Plates, manufactured at the Essen Works, Rhenish Prussia, and of those manufactured in Yo I requested to be provided with pieces not less than four feet by thr following thicknesses—as being those most generally in use for boiler ı three-eight inch, half-inch, and five-eight inch; that three pieces of e sent of those made at Essen, and one of each thickness from six York piece to have the Maker's Brand.

I accordingly received nine pieces branded "Krupp **," and t having the following brands :—"Low Moor," "Bowling, Yorksh "Taylor's • Leeds • Yorkshire," "Cooper & Co., Leeds • Yorkshire," Yorkshire." Total number of plates being twenty-seven.

The position of ten specimens were marked out on each plate, and numbers were all carefully stamped on each before commencing to c specimens, so as to prevent the possibility of any subsequent confus specimens were sheared off, but all were cut in a slotting machine, so a texture of the iron.

The ten specimens from each plate were for the following test specimens for subjecting to Pulling stress, two being cut out len crossway of the plate, one of each being tested in the same conditi unannealed, the others after being heated and annealed. Two for E for testing unannealed, the other annealed. Four for Bending stress, o one crossway of the plate for being tested cold, and two when heated t Those specimens that were annealed were heated to a "blood red," a time in a large air furnace, they were placed on a circular table, whic as to insure all the specimens being uniformly heated, and they w until the furnace was cold.

The pieces of plate remaining, after the foregoing tests were sequently prepared for ascertaining the differences between holes that those that were Punched, thereby adding materially to the completenes

Every specimen was measured, tested, and the results fully re personally, and in a series of tabulated reports I have given, in the form I could devise, the numerical results. The whole of the th twenty-four specimens are carefully preserved, and may be seen in Fractures. I shall now proceed to analyze and direct attention to t elicited during this inquiry.

REPORTS A, B, C, D.

ASCERTAIN THE ELASTIC AND ULTIMATE STRENGTH, SOFTNESS, AND DUCTILITY UNDER PULLING STRESS.

E one-hundred-and-eight specimens were all accurately prepared to the form
by the accompanying woodcuts, having the shoulders at each end carefully turned
e a fair and direct pull when being tested. Length of each specimen, extreme,
hes; between heads, 12·0 inches; and for ascertaining the rates of extension,
hes, Breadth, extreme, 4·5 inches; central portion, 2·00 inches. The results of
lividual plate are given in Reports A, B, C, and a general summary of the mean
of each group in Report D. We will proceed to consider—

stly. As regards the Elastic stress, or the elastic limit, or the amount of load
h the elasticity of the specimen becomes impaired. The nine Essen plates give
mean of 26,199 lbs. per square inch of sectional area when tested lengthway
plates, and in the same condition as received, and 24,577 lbs. after being
l, when tested crossway of the plate, as received, 25,655 lbs., and 24,144 lbs.
nnealed, mean of the whole being 25,144 lbs. The eighteen Yorkshire plates
under the same conditions, and in same order, 27,910, 27,005, 27,883, 27,111,
the whole being 27,477 lbs. The difference of 2,333 lbs. per square inch, or
cent., being caused by the additional hardness of the Yorkshire plates.

ondly. As regards the Ultimate stress, or the greatest load sustained by the
n previous to being fractured, and taking the results in the same order, we find
nine Essen plates yielded the following averages: 50,924, 46,760, 48,718, 45,711,
the whole being 48,028 lbs. per square inch. The eighteen Yorkshire plates,
45,204, 45,659, 43,282, mean of the whole being 45,515 lbs. The difference in
f Essen being 2,513 lbs. per square inch, or 5·5 per cent.

rdly. As regards the relative Softness of the plates, as shown by the Contraction
at Fracture, the Essen plates yielded the following averages: 39·6, 43·7, 24·8,
an of the whole being 33·8 per cent. of the original area of the specimen. The
re plates 20·6, 22·2, 14·7, 16·9, mean of the whole 18·6; difference in favour of
eing 15·2 per cent.

rthly. As regards the Ultimate stress per square inch of the specimens'
ed area: Essen 85,144, 83,759, 65,359, 63,907, total mean 74,542 lbs.; York-
,140, 59,428, 54,110, 52,823, total mean 56,875 lbs.; difference in favour of
eing 17,667 lbs., or 31·1 per cent.

thly. As regards the relative Ductility as indicated by the ultimate Extension
pecimens when broken: Essen 25·4, 28·2, 17·4, 19·7, total mean 22·7 per cent.
original length; Yorkshire 16·7, 18·4, 11·2, 12·8, total mean 14·8 per cent.;
e in favour of Essen being 7·9 per cent.

REPORT E.

To Ascertain the Effects produced by Drilled Holes and by under Pulling Stress.

The accompanying woodcuts represent the shape of the fifty-fo two rows of rivet-holes in the central portion, two-and-a-half inches a centres, and the pitch of the four holes across the plate being two inc being to exhibit the elongation of the holes after the plate was p other that without being fractured. The punched holes were conic larger on the exit than on the entrance side of the plate. Those dri exactly to the smaller size, and thus suitable for the same sized riv holes ·85 inch × 4 = 3·40 inches, or 42·5 per cent. of the width 8·00 inches being the total width of the central portion. In the "Size of the Specimen" it will be observed that the space occupied b *not* deducted as customary in making calculations on riveted-joints, and not the net area is stated. My reasons for doing so will presently app

In preceding reports, and in the remarks thereupon, the Stress i Square-inch of the specimen's sectional area; to have given the To each would only have complicated the tables without being of any re series now to be examined it was, however, better to give the tot each, so that any one can divide it by the net area, instead of the prefer to do so.

The strength of the solid plate, or that without the holes, is tal reports, and is given in the last column to facilitate comparison between that of the solid plate and that with the holes represents t latter. It has already been stated in former paragraph that in forn 42·5 per cent. of the plate was removed. Now let us see the *actual* by these experiments.

In the four Essen specimens with Drilled-holes, we find a mean lo when tested lengthway of the plate, and 38·9 per cent. when crossway 38·05 per cent. In the nine Yorkshire under the same conditions, 43 42·95 per cent; this loss agreeing very nearly with 42·50 per cen material removed. Such, however, is not the case with the Essen pla a mean loss of only 38·05 instead of 42·50, difference being 4·4 difference, however, is entirely due to the fact of the material being ultimate stress borne by a specimen is greatly affected by the ha of the material, and by the Shape of the specimen. The softer the rapidly does its sectional area become reduced by the specime consequently, in the amount of Stress sustained. When the breadth reduced to a minimum at one point a greater resistance is offered to

ɔrmed parallel for some distance; and as the stretching is checked so will also traction of area, and with it will be an increase in the ultimate stress. In the series of experiments, Reports A, B, C, D, the sides of the specimens being they stretched more, and the Essen specimens being very considerably softer e Yorkshire, their area became more reduced, and, accordingly, the stress borne m was less than it would otherwise have been. In the present series the ng of the specimens being confined to the material left between the rivet-holes ːhe specimens, the sectional area was not so much reduced as were the parallel ɜns, and, consequently, held a proportionately higher stress, thus accounting for ; of 38·05 per cent., being less than the 42·50 per cent. due to amount of material d by the rivet-holes.

e will now consider the results relating to the Punched holes. The five Essen ɜns tested lengthway show a mean loss of 48·5, crossway 50·0; mean 49·25 per The six Yorkshire 50·0 and 52·4; mean 51·2 per cent. The mean loss in the one ɔeing 6·75, in the other 8·70 per cent. more than that due simply to the number . This loss is partly due to the injury done to the iron surrounding the holes, and lue to the punching making the holes conical instead of parallel, thus removing ıaterial than in those which were Drilled. The loss in the Essen specimens was ıat less than in the others, owing to their being of softer quality.

ırning now to the Elongation of the holes that were Drilled, we have, for the 30·7 and 22·8, total mean 26·75 per cent., and Yorkshire 18·2 and 13·4, mean ɔer cent., difference in favour of the Essen being 10·95 per cent. To those that 'unched, for Essen 13·7 and 11·1, mean 12·4 per cent. Yorkshire, 8·3 and 7·0, ·65; difference in favour of the Essen plates being 4·75 per cent.

REPORT F.

To ascertain the Resistance to and Effects under Bulgi

The fifty-four specimens for the above tests were discs, twelve ir out in the lathe, and pressed into an aperture ten inches diameter in n machine, the end of the bulger being turned to a radius of five woodcuts which accompany the tabulated results show the form of the to, and after the experiment. Two specimens for this test were cut (the Maker's Brand being on one of them; one was tested as sent, una after being heated and annealed. The stress was gradually increased was pushed through the aperture or until the specimen gave way eit bursting.

Sixteen out of the eighteen specimens or 88·8 per cent. cut out o passed through the aperture without being cracked, the other two or 11 but not until they had very nearly passed, having been bulged, one t unannealed, the other 3·35 inches when annealed; with 3·52 inches passed through. Twelve out of the thirty-six Yorkshire plates, or 33· through uncracked, four or 11·1 per cent. cracked when bulged to a m the remaining twenty or 55·5 per cent. burst—the lowest when only l the highest, 3·30 inches; the mean being of 2·43 inches. Of those that aperture uncracked, we have 88·8 per cent. Essen, against 33·3 per ce of these cracked or burst, 11·1 per cent. of Essen, against 66·6 per cen

The mean thicknesses of the Essen specimens were ·440, ·533, whole ·542 inch; that of the Yorkshire ·390, ·510, ·625, total mea mean Ultimate stress reached being for Essen 139,093, 163,96 173,487 lbs. when tested unannealed, and 124,090, 159,683, 198,926, when annealed, total mean being 167,194 lbs. For the Yorkshire circumstances, 91,805, 136,711, 165,375, mean 131,297 lbs. unanne 125,096, 173,128, mean 134,768 lbs. annealed, total mean 133,033 lb with a mean thickness of ·542 inch in the Essen plates, a mean 167,194, against 133,033 lbs., with ·508 inch mean thickness in the Dividing the stress by the thickness we have 308,476 against 2(difference in favour of Essen of 17·8 per cent.

REPORT G.

:o ascertain the Resistance to and Effects under Bending Stress.

:se one-hundred-and-eight experiments were made in order to meet the ty requirements regarding Cold and Hot Bending tests. They were not, , bent by the blows of a hammer, which I have always considered objectionable, ery much depends upon the skill of the workman, the force, the number and of the blows, whether a specimen stands or does not stand being bent to the . angle. Two strips were cut out lengthway of each plate, and two crossway, edges planed parallel, and all exactly two-and-a-half inches wide. The specimens ıced against supports ten inches apart, in my Testing-machine, and loaded in re, as represented in the woodcuts, until the specimen dropped through between ;, having been bent, as shewn by the dotted lines. They were then replaced in ing-machine, and the ends of those specimens tested *cold* were pressed, as in ;, until the distance apart was four times the nominal thickness of the plate, l the specimen remained uncracked; those tested *hot* were doubled up and together, as shown by the other woodcut. The specimens bent hot were all o as nearly the same colour, " cherry-red," as was practicable.

:erring to specimens tested Cold, thirteen out of the eighteen, or 72·2 per cent. ssen strips were bent as stated, without the slightest crack; three, or 16·6 per ere very slightly cracked, and two, or 11·1 per cent., were cracked; all being bent degrees. Five out of the thirty-six, or 13·8 per cent., of the Yorkshire were ed; six, or 16·6 per cent., were cracked slightly, these eleven stood bending to rees; twenty-five, or 69·4 per cent., were cracked, the lowest on reaching an 50 degrees, the highest 180 degrees, mean of the twenty-five being 141 degrees. e uncracked, we have 72·2 of the Essen against 13·8, the difference in favour of hus being 58·4 per cent.

those tested Hot, being doubled up and pressed together, seventeen, or 94·4 per f the Essen strips were uncracked, and one, or 5·5 per cent., cracked slightly. , or 55·5 per cent. of the Yorkshire were uncracked, six, or 16·6 per cent., cracked ; five, or 13·8 per cent. cracked; three, or 8·3 per cent. were cracked badly; o, or 5·5 per cent. were nearly separated. Of those uncracked, we have 94·4 of en against 55·5 of the Yorkshire, difference in favour of Essen 38·9 per cent.

comparing the amount of Stress, we have for those tested Cold, lengthway ssway of plate, for Essen 2553. 2445, 3211, 3061, 4718, 4735, total mean s., with a total mean thickness of plate ·548 inch. Yorkshire strips 1552, 2203, 2360, 4415, 4281, total mean 2743 lbs. with ·507 mean thickness. g the stress by the thickness we obtain 6303 for the first, and 5410 for the ; difference in favour of Essen being 16·5 per cent. Similarly comparing those Hot, we have 532, 605, 742, 672, 1049, 1020, total mean 770 lbs. for Essen, and 8, 654, 622, 746, 828, total mean 640 lbs. for Yorkshire. Dividing the stress by kness we have 1405 against 1262; difference in favour of Essen 11·3 per cent.

CONCLUDING REMARKS.

SUMMING up the various facts obtained during this inquiry, stated reports and in the remarks thereupon, we have the following total mea

			ESSEN.
PULLING STRESS	Reports A, B, C, D	Elastic Stress	25,144 l
		Ultimate Stress	48,028 d
		Stress per Fractured Area	74,542 d
		Contraction of Area	33·8 per c
		Extension at 30,000 lbs.	1·94 do
		Extension at 40,000 lbs.	7·76 do
		Extension Ultimate	22·70 do
PULLING STRESS	Report E	Loss due to Holes, Drilled	38·05 do
		do. do: Punched	49·25 do
		Elongation of Holes, Drilled	26·75 do
		do. do. Punched	12·40 do
BULGING STRESS	Report F	Uncracked	88·8 do
		Cracked or Burst	11·1 do
		Bulged	3·36 inch
		Thickness	·542 inc
		Ultimate Stress	167,194 l
BENDING STRESS	Report G	Tested Cold, Uncracked	72·2 per c
		do. do. Cracked	27·7 per c
		do. do. Angle	180 degr
		do. do. Thickness	·548 inc
		do. do. Ultimate Stress	3454 lb
		Tested Hot, Uncracked	94·4 per c
		do. do. Cracked	5·5 per c
		do. do. Angle	180 degr
		do. do. Thickness	·548 incl
		do. do. Ultimate Stress	770 lbs.

ɜse varied differences between the Essen and the Yorkshire plates are fully by the appearance presented by their respective fractures. The Essen plates ng generally a lighter shade than the others, and much more uniform. The re plates presenting layers of several shades, some being considerably darker ɜ others, whilst many of the specimens are chiefly composed of dark layers. tabulated reports, the different Yorkshire Firms are placed in their respective merit, as nearly as practicable, from the results of their individual specimens.

ally, I beg to state that none of the facts ascertained throughout this inquiry ɜen concealed, but that I have presented the whole in the most suitable form ıparison, and in order that all may have the opportunity of judging for ves and of drawing their own conclusions.

AND EXPERIMENTING WORKS,
THWARK STREET, LONDON, S.E.,
31st December, 1875.

DAVID KIRKALDY.

TABULATED REPORTS.

REPORT A.

ıRY OF THE RESULTS OF EXPERIMENTS TO ASCERTAIN THE ELASTIC

NOMINAL THICKNESS—

LENGTHWAY.

	Test No.	Thick-ness.	STRESS. Elastic, per square inch.		Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTENSION, SET At 30,000 lbs. per square inch.	At 40,000 lbs. per square inch.	Ultimate.	APPEARANCE OF FRACTURE.
	J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent	lbs.	per cent.	per cent.	per cent.	
p	1559	·44	29,500	13·1	54,540	24·3	54·0	39·3	89,878	0·40	3·77	26·1	Fibrous.
	1549	·44	28,300	12·6	52,595	23·5	53·8	44·3	94,455	0·62	4·80	29·8	do.
	1539	·44	27,500	12·2	50,215	22·4	54·7	43·4	88,733	0·79	6·08	27·7	do.
	Mean	**·440**	**28,433**	**12·7**	**52,450**	**23·4**	**54·2**	**42·3**	**91,022**	**0·60**	**4·88**	**27·8**	
ng	1878	·40	32,900	14 7	57,415	25·6	57·3	29·5	81,439	0·10	2·82	22·6	Fibrous.
r's	1938	·39	29,500	13·2	50,865	22·7	57·9	19·7	63,378	0·19	4·71	19·5	do.
ɔor	1848	·38	25,800	11 5	47,050	21·0	54·8	30·5	67,723	2·30	8·30	24·4	do.
·idge	1998	·37	28,300	12·6	47,845	21·3	59·1	19·4	59,205	0·37	5·00	14·3	do.
.ey	1908	·42	27,500	12·2	45,160	20·1	60·8	14·0	52,540	0·89	5·87	11·8	part do. flaw.
& Co.	1968	·38	27,500	12·2	45,080	20·1	61·0	18·4	55,259	0·72	5·29	12·2	dark do. layers.
	Mean	**·390**	**28,583**	**12·7**	**48,902**	**21·8**	**58·5**	**21·9**	**63,257**	**0·76**	**5·33**	**17·5**	
ɔp	1550	·44	25,900	11·9	46,435	20·7	55·7	50·5	93,937	2·75	8·61	31·0	Fibrous.
	1560	·44	25,700	11·5	46,290	20·6	55·5	45·7	85,398	2·80	8·70	29·3	do.
	1540	·44	24,500	11·0	45,070	20·1	54·3	42·2	78,074	3·23	9·98	27·3	do.
	Mean	**·440**	**25,366**	**11·3**	**45,932**	**20·9**	**55·2**	**46·1**	**85,803**	**2·93**	**9·09**	**29·2**	
ing	1879	·39	29,300	13·1	50,260	22·4	58·2	26·0	67,942	0·21	5·40	20·6	Fibrous.
ɔr's	1939	·39	28,700	12·7	49,140	21·9	58·4	36·1	76,966	0·25	6·65	26·3	do.
ıoor	1849	·38	23,200	10·4	43,580	19·4	53·2	30·1	62,374	3·50	12·20	25·4	do.
·idge	1999	·37	24,900	11·1	44,020	19·6	56·5	23·7	57,756	1·37	7·65	20·1	do.
& Co.	1969	·38	26,300	11·7	41,905	18·7	62·7	13·7	48,548	2·11	9·18	12·5	dark do. layers.
.ley	1909	·41	24,600	11·0	40,105	17·9	61·3	12·5	45,866	2.60	10·10	11·0	dark do. layers.
	Mean	·386	26,166	11·6	44,835	20·0	58·4	23·7	59,908	1·67	8·53	19·3	

ED. KRUPP, ESQ.,

ESSEN WORKS, RHENISH PRUSSIA;

2 CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

REPORT A.

AND ULTIMATE TENSILE STRENGTH OF NINE WROUGHT-IRC

THREE-EIGHT INCH.

CROSSWAY.

DESCRIPTION.	Brand.	Test No.	Thickness.	STRESS. Elastic, per square inch.		STRESS. Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTE At 80,000 lbs. per square inch.	40 per
		J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.	p
UNANNEALED.	Krupp	1551	·44	28,800	12·8	50,195	22·4	57·3	27·2	69,018	0·22	
	do.	1561	·44	27,700	12·4	50,430	22 5	54·9	23·1	65,648	0·40	
	do.	1541	·44	26,400	11·8	47,240	21·1	55·8	16·8	56,791	0·60	
		Mean	·440	27,633	12·3	49,288	22·0	56·0	22·3	63,891	0·41	
	Bowling	1880	·41	29,800	13·3	51,610	23·0	57·7	30·3	74,115	0·13	
	Farnley	1910	·40	29,100	13·0	50,840	22·7	57·2	23·1	66,133	0·21	
	Lowmoor	1850	·38	27,300	12·2	48,460	21·6	56·3	15·9	57,636	0·57	
	Taylor's	1940	·39	28,500	12·7	41,095	18·4	69·3	7·9	44,643	0·29	
	Monkbridge	2000	·37	27,200	12·2	40,140	17·9	67·7	7·8	43,555	0·59	
	Cooper & Co.	1970	·38	26,600	11·9	40,070	18·4	66·3	8·1	43,629	1·00	
		Mean	·388	28,083	12·5	45,369	20·2	62·4	15·5	54,952	0·46	
ANNEALED.	Krupp	1552	·44	24,800	11·1	47,905	21·4	51·7	29·3	67,775	1·70	
	do.	1542	·44	24,600	11.0	44,945	20·1	54·7	20·7	56,022	1·91	
	do.	1562	·44	23,500	10·5	44,860	20·0	52·3	16·3	53,636	2·48	
		Mean	·440	24,300	10·9	45,903	20·5	52·9	23·1	59,144	2·03	
	Farnley	1911	·40	29,300	13·1	46,890	20·9	62·4	26·6	63,704	0·18	
	Bowling	1881	·41	29,500	13·2	46,915	20·9	62·8	22·4	60,358	0·11	
	Lowmoor	1851	·38	26,200	11·7	44,840	20·0	58·4	14·8	52,671	2·17	
	Monkbridge	2001	·37	27,000	12·1	40,970	18·2	65·9	11·3	46,216	0·76	
	Cooper & Co.	1971	·38	25,800	11·5	35,980	16·1	71·7	7·6	38,952	1·29	
	Taylor's	1941	·39	25,600	11·4	35,060	15·6	73·0	8·9	38,516	1·28	
		Mean	·388	27,233	12·2	41,776	18·6	65·7	15·2	50,069	0·96	

Length for Extension, 10 incl

99 SOUTHWARK STREET, LONDON, S.E., 17th September, 1875.

DAVID KIRKALI

REPORT B.

ɪY OF THE RESULTS OF EXPERIMENTS TO ASCERTAIN THE ELASTIC

NOMINAL THICKNESS,

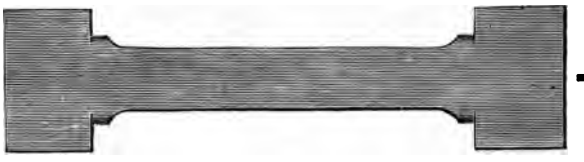
LENGTHWAY.

	Test No.	Thick-ness.	STRESS, Elastic, per square inch.		STRESS, Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTENSION, SET At 30,000 lbs. per square inch.	EXTENSION, SET At 40,000 lbs. per square inch.	EXTENSION, SET Ultimate.	APPEARANCE OF FRACTURE.
	J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.	per cent.	per cent.	
	1579	·54	25,900	11·6	52,275	23·3	49·5	32·3	77,232	1·19	4·24	24·1	Fibrous.
	1589	·53	25,600	11·5	52,445	23·4	48·8	37·3	83,722	1·38	4·33	26·2	do.
	1569	·53	25,200	11·2	51,780	23·1	48·6	44·4	93,186	1·50	4·80	27·6	do.
	Mean	**·533**	**25,566**	**11·3**	**52,167**	**23·2**	**48·9**	**38·0**	**84,713**	**1·36**	**4·46**	**25·9**	
	1858	·50	26,800	12·0	51,740	23·1	51·7	27·9	71,761	0·79	4·00	19·5	Fibrous.
	1948	·51	28,200	12·6	47,770	21·2	59·0	34·9	73,380	0·32	6·80	21·9	do.
	1918	·52	28,700	12·8	50,785	22·6	56·5	19·5	63,102	0·21	4·12	17·8	do.
)o.	1978	·53	28,600	12·7	45,580	20·3	62·7	18·0	55,598	0·21	6·82	14·9	def. do. welds.
	1898	·49	26,500	11·8	44,310	19·8	59·8	17·7	53,875	1·48	7·10	14·2	dark do. layers.
ge	2008	·51	27,900	12·5	44,215	19·7	63·1	11·5	50,000	0·40	5·92	10·7	dark do. layers.
	Mean	**·510**	**27,783**	**12·4**	**47,400**	**21·1**	**58·8**	**21·6**	**61,286**	**0·57**	**5·79**	**16·5**	
	1570	·53	24,300	10·9	46,605	20·8	51·0	49·7	94,674	2·60	7·55	29·2	Fibrous.
	1590	·53	24,600	11·0	47,430	21·1	51·8	47·6	90,586	2·52	7·50	26·2	do.
	1580	·54	24,900	11·1	46,635	20·8	53·3	38·1	75,377	2·50	7·92	23·8	do.
	Mean	**·533**	**24,600**	**11·0**	**47,223**	**21·1**	**52·0**	**45·1**	**86,879**	**2·54**	**7·66**	**26·4**	
	1859	·49	26,400	11·7	46,355	20·7	56·0	33·2	69,461	1·70	8·22	23·1	Fibrous
	1919	·52	28,100	12·5	47,285	21·1	59·3	28·0	65,882	0·80	7·37	22·6	do.
)o.	1979	·53	28,500	12·7	45,870	20·5	62·1	21·0	58,091	0·41	7·60	18·6	do.
	1949	·51	26,800	12·0	43,405	19·4	61·7	26·2	58,873	2·28	12·00	21·5	dark do. layers.
ge	2009	·50	27,600	12·3	44,485	19·8	62·0	17·3	53,790	0·70	7·43	13·1	dark do. layers
	1889	·48	23,800	10·6	41,980	18·7	56·6	7·2	51,013	3·20	13·00	18·1	dark do. layers.
	Mean	**·505**	**26,866**	**12·0**	**44,913**	**20·1**	**59·6**	**22·1**	**59,518**	**1·51**	**9·27**	**19·5**	

). KRUPP, ESQ.,

SEN WORKS, RHENISH PRUSSIA;

CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.



REPORT B.

AND ULTIMATE TENSILE STRENGTH OF NINE WROUGHT-I

HALF-INCH.

DESCRIPTION.	CROSSWAY.										
	Brand.	Test No.	Thickness.	STRESS. Elastic, per square inch.		Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EX' At 30,000 lbs. per square inch.
		J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.
UNANNEALED.	Krupp	1571	·52	25,400	11·4	52,135	23·3	48·7	28·0	72,487	1·02
	do.	1591	·53	25,300	11·3	51,445	22·9	49·1	25·7	69,290	1·20
	do.	1581	·54	25,100	11·1	47,340	21·1	53·0	21·2	60,078	1.81
		Mean	·530	25,266	11·2	50,307	22·4	50·2	24·9	67,285	1·34
	Farnley	1920	·49	29,800	13·4	56,470	25·2	52·7	15·1	66,514	0·17
	Monkbridge	2010	·51	29,100	13·0	45,590	20·3	63·8	16·1	52,542	0·19
	Taylor's	1950	·51	28,700	12·8	45,965	20·5	62·4	8·2	50,000	0·22
	Cooper & Co.	1980	·52	28,200	12·6	42,810	19·8	65·8	14·6	50,137	0·60
	Bowling	1890	·50	26,300	11·7	40,920	18·2	64·2	8·8	44,868	0·60
	Lowmoor	1860	·50	29,100	13·0	40,145	17·9	65·0	14·9	47,173	0·88
		Mean	·505	28,033	12·5	45,316	20·2	62·3	12·9	51,887	0·44
ANNEALED.	Krupp	1592	·53	24,500	11·0	46,745	20·8	52·4	35·3	72,335	2·41
	do.	1582	·53	24,700	11·1	46,985	20·9	52·5	20·3	60,911	2·30
	do.	1572	·52	24,400	10·9	44,940	20·1	54·2	27·2	61,740	2·40
		Mean	·526	24,533	11·0	46,223	20·6	53·0	27·6	64,995	2·37
	Farnley	1921	·49	29,600	13·2	49,870	22·2	59·3	25·5	68,291	0·20
	Lowmoor	1861	·50	26,200	11·6	44,660	19·9	58·6	32·8	64,970	1·40
	Taylor's	1951	·51	27,100	12·1	44,605	19·9	60·7	20·5	56,181	1·20
	Monkbridge	2011	·50	28,500	12·7	46,590	20·7	61·1	14·1	54,237	0·48
	Cooper & Co.	1981	·51	27,800	12·4	40,825	18·2	67·9	12·4	46,699	0·89
	Bowling	1891	·50	24,300	10·9	38,365	17·1	63·3	9·8	42,533	1·91
		Mean	·501	27,350	12·1	44,164	19·6	61·8	19·2	55,485	1·01

Length for Extensions, 10 inc

99 SOUTHWARK STREET, LONDON, S.E., 17th September, 1875. DAVID KIRKA

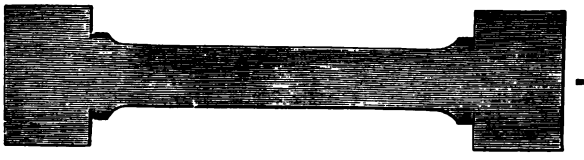
REPORT C.

ɪY OF THE RESULTS OF EXPERIMENTS TO ASCERTAIN THE ELASTIC

NOMINAL THICKNESS—

LENGTHWAY.

	Test No.	Thick-ness.	STRESS. Elastic, per square inch.		STRESS. Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTENSION, SET At 30,000 lbs. per square inch.	EXTENSION, SET At 40,000 lbs. per square inch.	EXTENSION, SET Ultimate.	APPEARANCE OF FRACTURE.
	J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.	per cent.	per cent.	
	1619	·65	24,200	10·8	47,460	21·1	50·9	47·6	90,599	2·48	7·97	29·8	Fibrous.
	1609	·66	25,400	11·4	49,935	22·2	50·8	39·7	82,911	1·40	4·82	22·1	do.
	1599	·65	24,200	10·8	47,070	21·0	51·4	28·2	65,585	1·97	6·43	16·4	def. do. weld.
	Mean	**·653**	**24,600**	**11·0**	**48,155**	**21·5**	**51·0**	**38·5**	**79,698**	**1·95**	**6·41**	**22·7**	
r	1868	·63	28,600	12·7	50,405	22·5	56·7	20·9	66,433	0·40	5·10	21·6	Fibrous.
	1898	·62	26,800	12·0	50,030	22·4	53·5	21·2	63,497	0·60	5·32	20 4	do.
	1958	·63	26,500	11·9	49,465	22·1	53·5	24·7	63,491	0·64	5·76	23·0	do.
)o.	1988	·63	25,300	11·3	47,770	21·2	52·9	21·0	60,492	0·98	5·83	15·6	dark do. layers.
	1928	·64	29,200	13·0	47,760	21·2	61·1	14·8	56,085	0·21	3·88	10·2	dark do. layers.
ge	2018	·61	27,800	12·4	39,233	17·6	70·8	8·7	43,263	1·02	....	6·5	dark do. layers.
	Mean	**·627**	**27,366**	**12·2**	**47,444**	**21·2**	**58·1**	**18·5**	**58,877**	**0·64**	**5·18**	**16·2**	
	1620	·65	23,200	10·4	46,215	20·6	50·2	43·1	81,298	3·04	9·90	32·1	Fibrous.
	1600	·63	23,500	10·5	46,890	20·9	50·1	40·1	78,357	2·81	8·20	29·7	do.
	1610	·66	24,600	11·0	48,275	21·6	50·9	36·5	76,132	2·22	7·28	25·9	do.
	Mean	**·646**	**23,766**	**10·7**	**47,126**	**21·0**	**50·4**	**39·9**	**78,596**	**2·69**	**8·46**	**29·2**	
r	1869	·63	29,200	13·0	52,060	23·2	56·0	29·6	73,952	0·33	5·30	23·4	Fibrous.
;	1899	·62	26,100	11·6	47,860	21·3	54·5	28·7	65,906	2·20	7·11	22·7	do.
	1959	·63	27,500	12·2	47,405	21·1	58·0	21·9	60,763	1·55	6·94	23·5	do.
)o.	1989	·63	29,400	13·1	46,240	20·6	60·3	16·9	55,647	0·12	5·05	12·0	dark do. layers.
	1929	·64	28,500	12·7	44,920	20·1	63·4	15·7	53,287	0·28	7·28	13·2	dark do. layers.
ge	2019	·60	27,200	12·1	36,700	16·4	74·0	13·8	42,593	1·99	....	5·1	dark, do. flaw.
	Mean	**·625**	**27,983**	**12·5**	**45,866**	**20·2**	**61·0**	**21·0**	**58,858**	**1·08**	**6·33**	**16·6**	



KRUPP, ESQ.,

ɛN WORKS, RHENISH PRUSSIA;

ROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

REPORT C.

AND ULTIMATE TENSILE STRENGTH OF NINE WROUGHT-IRON

Five-eight Inch.

Description.	Brand.	Test No.	Thickness.	CROSSWAY. STRESS. Elastic, per square inch.		Ultimate, per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTENSI At 30,000 lbs. per square inch.	At 40,000 per squ inch
		J	inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.	per ce
UNANNEALED.	Krupp	1621	·65	24,200	10·8	46,635	20·8	51·8	37·2	74,295	2·60	8·0
	do.	1611	·66	24,600	11·0	47,860	21·3	51·3	27·5	66,013	2·11	6·4
	do.	1601	·65	23,400	10·4	45,190	20·1	51·7	16·9	54,395	2·20	6·8
		Mean	**·653**	**24,066**	**10·7**	**46,561**	**20·8**	**51·6**	**27·2**	**64,901**	**2·30**	**7·1**
	Lowmoor	1870	·63	29,500	13·2	51,390	22 9	57·4	23·2	66,961	0·11	4·1
	Bowling	1900	·61	24,800	11·1	46,780	20·9	53·0	21·9	59,948	1·70	6·2
	Cooper & Co.	1990	·63	28,600	12·7	47,020	21·0	60·8	17·9	57,296	0·30	5·0
	Farnley	1930	·63	27,500	12·3	47,345	21·1	58·0	11·9	53,791	0 60	4·5
	Monkbridge	2020	·61	28,200	12·6	43,635	19·0	64·6	13·0	50,174	0·40	5·7
	Taylor's	1960	·63	26,600	11·9	41,590	18·5	63·9	7·1	44,788	0·68	5·7
		Mean	**·623**	**27,533**	**12 2**	**46,293**	**20·6**	**59·6**	**15·8**	**55,493**	**0·63**	**5·2**
ANNEALED.	Krupp	1622	·65	24,500	11·0	45,110	20·1	54·3	44·6	81,448	2·98	9·9
	do.	1612	·65	23,600	10·5	45,690	20·3	51·6	32·7	67,958	2·64	8·0
	do.	1602	·64	22,700	10·1	44,220	19·7	51·3	17·1	53,347	2·50	7·8
		Mean	**·646**	**23,600**	**10·5**	**45,007**	**20·1**	**52·4**	**31·5**	**67,584**	**2·71**	**8·6**
	Lowmoor	1871	·63	29,200	13·0	48,020	21·5	60·8	26·8	65,623	0·16	5·3
	Bowling	1901	·60	24,180	10·7	41,335	18·5	58·3	20·6	52,102	3·91	14·2
	Cooper & Co.	1991	·62	27,800	12·4	44,860	20·0	61·9	14·6	52,576	0·60	5·8
	Farnley	1931	·63	27,100	12·1	43,940	19·6	61·6	11·1	49,476	1·03	5·9
	Monkbridge	2021	·61	27,400	12·2	42,735	19·1	64·1	15·9	50,815	0·82	6·7
	Taylor's	1961	·62	25,500	11·4	42,555	19·0	59·9	9·2	46,904	1·67	6·6
		Mean	**·618**	**26,850**	**12·0**	**43,907**	**19·6**	**61·1**	**16·3**	**52,916**	**1·36**	**7·4**

Length for Extensions, 10 inches

99 Southwark Street, London, S.E., 17th September, 1875. DAVID KIRKALDY

REPORT D.

L SUMMARY OF THE RESULTS OF EXPERIMENTS TO ASCERTAIN THE

NOMINAL THICKNESS—THREE-EIGHT,

LENGTHWAY.

	Number of Tests.	Thick-ness.	STRESS. Elastic. per square inch.		STRESS. Ultimate. per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EXTENSION, SET At 30,000 lbs. per square inch.	EXTENSION, SET At 40,000 lbs. per square inch.	EXTENSION, SET Ultimate.	APPEARANCE OF FRACTURE.
		inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.	per cent.	per cent.	
)	Mean of 3	·440	28,433	12·7	52,450	23·4	54·2	42·3	91,022	0·60	4·88	27·8	Fibrous.
	Mean of 3	·533	25,566	11·3	52,167	23·2	48·9	38·0	84,713	1·36	4·46	25·9	do.
	Mean of 3	·653	24,600	11·0	48,155	21·5	51·0	38·5	79,698	1·95	6·41	22·7	do.
	Mean of 9	·542	26,199	11·6	50,924	22·7	51·3	39·6	85,144	1·30	5·25	25·4	do.
re	Mean of 6	·390	28,583	12·7	48,902	21·8	58·5	21·9	63,257	0·76	5·33	17·5	Fibrous.
	Mean of 6	·510	27,783	12·4	47,400	21·1	58·8	21·6	61,286	0·57	5·79	16·5	do.
	Mean of 6	·627	27,366	12·2	47,444	21·2	58·1	18·5	58,877	0·64	5·18	16·2	do.
	Mean of 18	·509	27,910	12·4	47,915	21·3	58·4	20·6	61,140	0·65	5·43	16·7	do.
	Mean of 3	·440	25,366	11·3	45,932	20·9	55·2	46·1	85,803	2·93	9·09	29·2	Fibrous.
	Mean of 3	·533	24,600	11·0	47,223	21·1	52·0	45·1	86,879	2·54	7·66	26·4	do.
	Mean of 3	·646	23,766	10·7	47,126	21·0	50·4	39·9	78,596	2·69	8·46	29·2	do.
	Mean of 9	·539	24,577	11·0	46,760	21·0	52·5	43·7	83,759	2·72	8·40	28·2	do.
re	Mean of 6	·386	26,166	11·6	44,835	20·0	58·4	23·7	59,908	1·67	8·53	19·3	Fibrous.
	Mean of 6	·505	26,866	12·0	44,913	20·1	59·6	22·1	59,518	1.51	9·27	19·5	do.
	Mean of 6	·623	27,983	12·5	45,866	20·2	61·0	21·0	58,858	1·08	6·33	16·6	do.
	Mean of 18	·504	27,005	12·0	45,204	20·1	59·6	22·2	59,428	1·42	8·04	18·4	do.

KRUPP, ESQ.,

SEN WORKS, RHENISH PRUSSIA;

CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

REPORT D.

ELASTIC AND ULTIMATE TENSILE STRENGTH OF WROUGHT-

HALF, AND FIVE-EIGHT INCH.

CROSSWAY.

Description.	Brand.	Number of Tests.	Thickness.	STRESS. Elastic. per square inch.		STRESS. Ultimate. per square inch.		Ratio of Elastic to Ultimate.	Contraction of Area at Fracture.	Stress per square inch of Fractured Area.	EX At 30,000 lbs. per square inch.
			inch.	lbs.	tons.	lbs.	tons.	per cent.	per cent.	lbs.	per cent.
UNANNEALED.	Krupp	Mean of 3	·440	27,633	12·3	49,288	22·0	56·0	22·3	63,891	0·41
	do.	Mean of 3	·530	25,266	11·2	50,307	22·4	50·2	24·9	67,285	1·34
	do.	Mean of 3	·653	24,066	10·7	46,561	20·8	51·6	27·2	64,901	2·30
		Mean of 9	·541	25,655	11·4	48,718	21·7	52·6	24·8	65,359	1·35
	Yorkshire	Mean of 6	·388	28,083	12·5	45,369	20·2	62·4	15·5	54,952	0·46
	do.	Mean of 6	·505	28,033	12·5	45,316	20·6	62·3	12·9	51,887	0·44
	do.	Mean of 6	·623	27,533	12·2	46,293	20·6	59·6	15·8	55,493	0·63
		Mean of 18	·505	27,883	12·4	45,659	20·3	61·4	14·7	54,110	0·51
ANNEALED.	Krupp	Mean of 3	·440	24,300	10·9	45,903	20·5	52·9	22·1	59,144	2·03
	do.	Mean of 3	·526	24,533	11·0	46,223	20·6	53·0	27·6	64,995	2·37
	do.	Mean of 3	·646	23,600	10·5	45,007	20·1	52·4	31·5	67,584	2·71
		Mean of 9	·537	24,144	10·8	45,711	20·4	52·7	27·0	63,907	2·37
	Yorkshire	Mean of 6	·388	27,233	12·2	41,776	18·6	65·7	15·2	50,069	0·96
	do.	Mean of 6	·501	27,250	12·1	44,164	19·6	61·8	19·2	55,485	1·01
	do.	Mean of 6	·618	26,850	12·0	43,907	19·6	61·1	16·3	52,916	1·36
		Mean of 18	·502	27,111	12·1	43,282	19·2	62·8	16·9	52,823	0·81

Length for Extensions, 10 inches.

99 SOUTHWARK STREET, LONDON, S.E., 8th October, 1875.

DAVID KIRKALDY.

REPORT E.

ESULTS OF EXPERIMENTS TO ASCERTAIN THE EFFECTS PRODUCED

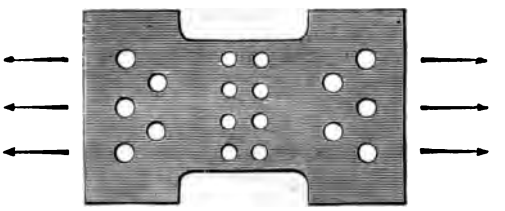
NOMINAL THICKNESSES—THREE-EIGHT,

DRILLED HOLES.

SIZE OF SPECIMEN.		Test	ULTIMATE STRESS.		DIFFERENCE OR LOSS.		ELONGATION OF HOLES.				APPEARANCE OF FRACTURE.	SOLID PLATE. ULTIMATE STRESS PER SQUARE INCH.
Holes not Deducted.	Gross Area.	No.	Total.	Per square inch.	Per square inch.	Per cent.	Fractured.	Unfractured.	Total.			
inches.	sq. in.	J	lbs.	lbs.	lbs.	per cent.	inch.	inch.	inch.	per cent.		lbs.
8·00 × ·44	3·52	2687	116,180	**33,005**	19,590	**37·2**	·34	·18	·52	**30·6**	Fibrous	**52,595**
8·00 × ·53	4·24	2691	141,920	**33,471**	18,309	**35·3**	·32	·19	·51	**30·0**	do.	**51,780**
8·00 × ·53	4·24	2695	138,160	**32,584**	19,861	**37·8**	·35	·19	·54	**31·7**	do.	**52,445**
8·00 × ·66	5·28	2699	162,290	**30,736**	19,199	**38·4**	·35	·17	·52	**30·6**	do.	**49,935**
		Mean		**32,449**		**37·2**				**30·7**		**51,689**
8·00 × ·39	3·12	2709	99,960	**32,038**	25,377	**44·2**	·23	·11	·34	**20·0**	Fibrous	**57,415**
8·00 × ·39	3·12	2721	91,180	**29,224**	21,641	**42·5**	·26	·15	·41	**24·1**	do.	**50,865**
8·00 × ·37	2·96	2733	83,080	**28,067**	19,778	**41·3**	·15	·08	·23	**13·5**	do.	**47,845**
8·00 × ·50	4·00	2705	114,560	**28,640**	23,100	**44·6**	·20	·12	·32	**18·8**	do.	**51,740**
8·00 × ·51	4·08	2717	122,430	**30,007**	20,778	**40·9**	·21	·11	·32	**18·8**	do.	**50,785**
8·00 × ·52	4·16	2729	110,080	**26,461**	19,119	**42·0**	·20	·09	·29	**17·1**	do.	**45,580**
8·00 × ·63	5·04	2713	139,120	**27,603**	22,427	**44·8**	·23	·12	·35	**20·6**	do.	**50,030**
8·00 × ·63	5·04	2725	134,970	**26,779**	22,686	**45·8**	·23	·11	·34	**20·0**	do.	**49,465**
8·00 × ·61	4·88	2737	112,310	**23,015**	16,218	**41·3**	·14	·05	·19	**11·2**	dark do. layers	**39,233**
		Mean		**27,982**		**43·1**				**18·2**		**49,217**
8·00 × ·44	3·52	2688	105,790	**30,053**	20,142	**40·1**	·27	·13	·40	**23·5**	Fibrous	**50,195**
8·00 × ·53	4·24	2692	132,480	**31,245**	20,890	**39·5**	·25	·14	·39	**23·0**	do.	**52,135**
8·00 × ·53	4·24	2696	127,970	**30,182**	21,263	**40·1**	·23	·12	·35	**23·6**	do.	**51,445**
8·00 × ·66	5·28	2700	163,580	**30,981**	17,294	**35·8**	·26	·15	·41	**20·1**	do.	**48,275**
		Mean		**30,165**		**38·9**				**22·8**		**50,512**
8·00 × ·42	3·36	2710	99,640	**29,654**	21,956	**42·5**	·18	·08	·26	**15·3**	Fibrous	**51,610**
8·00 × ·39	3·12	2722	73,780	**23,647**	17,448	**42.4**	·15	·05	·20	**11·8**	do.	**41,095**
8·00 × ·38	3·04	2734	70,790	**23,286**	16,854	**42·0**	·11	·07	·18	**10·6**	do.	**40,140**
8·00 × ·50	4·00	2718	128,290	**32,072**	24,398	**43·2**	·19	·09	·28	**16·5**	do.	**56,470**
8·00 × ·53	4·24	2730	110,640	**26,094**	16,716	**39·0**	·15	·07	·22	**13·0**	dark do. layers	**42,810**
8·00 × ·50	4·00	2706	97,280	**24,320**	15,825	**39·4**	·21	·09	·30	**17·6**	dark do. layers	**40,145**
8·00 × ·63	5·04	2714	129,890	**25,772**	21,008	**44·9**	·18	·09	·27	**15·9**	do.	**46,780**
8·00 × ·63	5·04	2726	114,130	**22,644**	18,946	**45·5**	·12	·05	·17	**10·0**	dark do. layers	**41,590**
8·00 × ·60	4·80	2738	109,980	**22,912**	20,723	**47·4**	·12	·05	·17	**10·0**	dark do. layers	**43,635**
		Mean		**25,600**		**42·8**				**13·4**		**44,919**

led Holes were made exactly the same size as those Punched: Diameter

All the Specimens



). KRUPP, ESQ.,

ESSEN WORKS, RHENISH PRUSSIA;

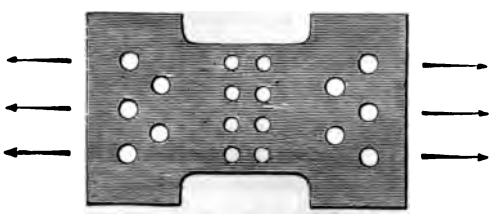
2 CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

BY DRILLED HOLES AND BY PUNCHED HOLES UNDER PULLI

Half, and Five-eight Inch.

PUNCHED HOLES.

Description.	Brand.	Size of Specimen. Holes not Deducted.	Gross Area.	Test No.	Ultimate Stress. Total.	Per square inch.	Difference or Loss. Per square inch.	Per cent.	Elongation of Holes. Fractured.	Unfractured.	Total.	
		inches.	sq. in.	J	lbs.	lbs.	lbs.	per cent.	inch.	inch.	inch.	per cent.
Lengthway.	Krupp	8·00 × ·44	3·52	2689	98,580	**28,006**	26,534	**48·6**	·17	·05	·22	**13·0**
	do.	8·00 × ·44	3·52	2685	90,160	**25,613**	24,602	**49·0**	·19	·06	·25	**14·7**
	do.	8·00 × ·54	4·32	2693	118,620	**27,458**	24,817	**47·4**	·18	·04	·22	**13·0**
	do.	8·00 × ·65	5·20	2701	126,290	**24,286**	23,174	**48·8**	·19	·07	·26	**15·3**
	do.	8·00 × ·65	5·20	2697	125,140	**24,065**	23,007	**48·8**	·16	·05	·21	**12·4**
				Mean		**25,885**		**48·5**				**13·7**
	Lowmoor	8·00 × ·38	3·04	2703	67,680	**22,263**	24,787	**52·6**	·16	·03	·19	**11·2**
	Farnley	8·00 × ·40	3·20	2715	69,130	**21,603**	23,557	**52·1**	·11	·02	·13	**7·7**
	Cooper & Co.	8·00 × ·39	3·12	2727	71,980	**23,070**	22,010	**48·8**	·10	·02	·12	**7·0**
	Taylor's	8·00 × ·52	4·16	2723	105,490	**25,358**	22,412	**46·9**	·14	·02	·16	**9·4**
	Bowling	8·00 × ·54	4·32	2711	100,610	**23,289**	21,021	**47·4**	·12	·02	·14	**8·2**
	Monkbridge	8·00 × ·51	4·08	2735	96,720	**23,705**	20,510	**46·4**	·11	·01	·12	**7·0**
	Lowmoor	8·00 × ·63	5·04	2707	120,830	**23,974**	26,431	**52·4**	·12	·02	·14	**8·2**
	Farnley	8·00 × ·63	5·04	2719	115,610	**22,938**	24,822	**51·9**	·12	·02	·14	**8·2**
	Cooper & Co.	8·00 × ·63	5·04	2713	118,420	**23,496**	24,274	**50·8**	·11	·02	·13	**7·7**
				Mean		**23,299**		**50·0**				**8·3**
Crossway.	Krupp	8·00 × ·44	3·52	2690	85,640	**24,329**	26,101	**51·7**	·15	·03	·18	**10·6**
	do.	8·00 × ·44	3·52	2686	80,180	**22,778**	24,462	**51·8**	·16	·05	·21	**12·4**
	do.	8·00 × ·54	4·32	2694	108,090	**25,021**	22,319	**47·1**	·14	·03	·17	**10·0**
	do.	8·00 × ·64	5·12	2698	120,280	**23,492**	23,398	**49·9**	·14	·03	·17	**10·0**
	do.	8·00 × ·64	5·12	2702	118,720	**23,187**	23,628	**49·8**	·17	·04	·21	**12·4**
				Mean		**23,761**		**50·0**				**11·1**
	Farnley	8·00 × ·41	3·28	2716	76,870	**23,436**	27,404	**53·9**	·13	·01	·14	**8·2**
	Lowmoor	8·00 × ·37	2·96	2704	64,440	**21,770**	26,690	**55·0**	·12	·01	·13	**7·7**
	Cooper & Co.	8·00 × ·39	3·12	2728	62,490	**20,028**	20,042	**50·0**	·09	·01	·10	**5·9**
	Taylor's	8·00 × ·53	4·24	2724	98,140	**23,046**	22,919	**50·0**	·12	·01	·13	**7·7**
	Bowling	8·00 × ·53	4·24	2712	85,870	**20,253**	20,668	**50·5**	·11	·01	·12	**7·0**
	Monkbridge	8·00 × ·50	4·00	2736	87,310	**21,827**	23,760	**52·1**	·11	·01	·12	**7·0**
	Lowmoor	8·00 × ·63	5·04	2708	122,340	**24,274**	27,116	**52·8**	·11	·01	·12	**7·0**
	Farnley	8·00 × ·63	5·04	2720	110,940	**22,011**	25,334	**53·5**	·10	·01	·11	**6·5**
	Cooper & Co.	8·00 × ·62	4·06	2732	108,720	**21,919**	25,101	**53·4**	·09	·01	·10	**5·9**
				Mean		**22,063**		**52·4**				**7·0**



·85 inch × 4 = 3·40 inches, or 42·5 per cent. of the width of were Unannealed.

99 Southwark Street, London, S.E., 30th November, 1875. DAVID KIRKALDY.

REPORT F.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO

NOMINAL THICKNESSES—THREE-EIGHT,

UNANNEALED.

	Test No.	Thickness.	STRESS IN POUNDS.—BULGED, INCHES.								ULTIMATE.		EFFECTS.
			25,000.	50,000.	75,000.	100,000.	125,000.	150,000.	175,000.	200,000.	Bulge.	Stress.	
	J	inch.									inches.	lbs	
p	1363	·44	0·81	1·34	1·75	2·12	2·58	....	....	....	3·28	139,940	Uncracked.
	1553	·44	0·82	1·35	1·79	2·15	2·64	....	....	....	3·28	139,780	do.
	1543	·44	0·82	1·36	1·80	2·16	2·67	....	....	....	3·26	137,560	do.
	Mean	**·440**	**0·82**	**1·35**	**1·78**	**2·14**	**2·63**	....	....	....	**3·27**	**139,093**	
ey	1912	·42	0·77	1·39	1·85	2·32	....	....	....	....	3·24	116,810	Uncracked.
oor	1852	·38	0·92	1·54	2·06	2·71	....	....	....	....	3·20	102,780	do.
ng	1882	·40	0·74	1·35	1·78	2·46	....	....	....	....	3·22	114,420	Cracked.
idge	2002	·37	0·86	1·47	1·97	2·51	....	....	....	....	2·75	110,880	Burst.
r's	1942	·39	0·80	1·42	....	....	....	....	....	....	1·84	54,720	do.
& Co.	1972	·38	0·85	1·47	....	....	....	....	....	....	1·65	51,220	do.
	Mean	**·390**	**0·83**	**1·44**	....	....	....	....	....	....	**2·65**	**91,805**	
p	1593	·53	0·65	1·20	1·50	1·85	2·16	2·59	....	....	3·41	165,110	Uncracked.
	1583	·54	0·66	1·24	1·60	1·94	2·29	2·68	....	....	3·39	164,230	do.
	1573	·53	0·60	1·10	1·46	1·79	2·12	2·58	....	....	3·39	162,550	do.
	Mean	**·533**	**0·64**	**1·18**	**1·52**	**1·86**	2 19	**2·62**	....	....	**3·40**	**163,963**	
ey	1922	·52	0·58	1·07	1·49	1·78	2 11	2·50	....	....	3·28	168,480	Uncracked.
r's	1952	·51	0·59	1·10	1·45	1·83	2·14	2·45	....	....	3·10	167,290	Burst.
& Co.	1982	·53	0·54	1·08	1·40	1·75	2·05	2·37	....	....	2·95	168,110	do.
oor	1862	·50	0·71	1·23	1·65	2·02	2·34	2·82	....	....	3·10	157,560	do.
idge	2012	·51	0·62	1·14	1·52	1·88	....	....	....	....	2·16	105,720	do.
ng	1892	·49	0·65	1·16	....	....	....	....	....	....	1·76	53,110	do.
	Mean	**·510**	**0·61**	**1·13**	**1·52**	**1·85**	....	....	....	....	**2·72**	**136,711**	
p	1603	·65	0·50	0·98	1·28	1·60	1·89	2·14	2·50	2·91	3·52	228,320	Uncracked.
	1623	·65	0·50	0·98	1·32	1·66	1·95	2·23	2·57	2·98	3·50	211,820	do.
	1613	·66	0·49	0·92	1·21	1·50	1·78	2·00	2·21	2·58	3·06	212,080	Burst.
	Mean	**·653**	**0·50**	**0·96**	**1·27**	**1·59**	**1·87**	**2·12**	**2·44**	**2·82**	**3·36**	**217,406**	
oor	1872	·63	0·35	0·92	1·28	1·58	1·85	2·13	2·34	2·59	3·30	239,040	Burst.
ng	1902	·62	0·44	0·98	1·37	1·68	1·94	2·21	2·48	2·87	3·08	208,140	do.
& Co.	1992	·63	0·31	0·89	1·24	1·55	1·85	2·14	2·51	3·03	3·07	212,270	do.
ey	1932	·64	0·30	0·86	1·22	1·49	1·75	2·00	2·22	....	2·72	194,740	do.
r's	1962	·63	0·34	0·95	1·30	....	....	....	....	....	1.56	85,770	do.
idge	2022	·60	0·38	0·98	....	.. .	....	....	....	....	1·40	52,290	do.
	Mean	**·625**	**0·35**	**0·93**	**1·28**	.. .	....	....	....	....	**2·52**	**165,375**	

). KRUPP, Esq.,

ESSEN WORKS, RHENISH PRUSSIA;

2 CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

Disc twelve inches diameter, cut out of plates

REPORT F.

BULGING STRESS OF TWENTY-SEVEN WROUGHT-IRON PLATES

HALF, AND FIVE-EIGHT INCH.

Nominal Thickness.	ANNEALED.											
	Brand.	Test No.	Thickness.	STRESS IN POUNDS.—BULGED, INCHES.								ULTI
				25,000.	50,000.	75,000.	100,000.	125,000.	150,000.	175,000.	200,000.	Bulge.
		J	inch.									inches.
THREE-EIGHT INCH.	Krupp	1544	·44	0·81	1·37	1·80	2·21	....	....	....	....	3·28
	do.	1564	·44	0·84	1·40	1·85	2·25	....	....	....	....	3·28
	do.	1554	·44	0·84	1·41	1·85	2·29	....	....	....	....	3·26
		Mean	**·440**	**0·83**	**1·39**	**1·83**	**2·25**	....	....	....	....	**3·27**
	Farnley	1913	·42	0·90	1·50	2·00	2·60	....	....	....	....	3·24
	Lowmoor	1853	·38	0·99	1·74	2·30	2·98	....	....	....	....	3·23
	Bowling	1883	·40	0·93	1·51	2·00	2·62	....	....	....	....	3·22
	Taylor's	1943	·39	0·92	1·57	2·06	2·65	....	....	....	....	3·21
	Monkbridge	2003	·37	0·94	1·60	2·15	2·82	....	....	....	....	3·16
	Cooper & Co.	1953	·38	0·92	1·58	2·08	2·74	....	....	....	....	3·07
		Mean	**·390**	**0·93**	**1·58**	**2·09**	**2·73**	....	....	....	....	**3·19**
HALF-INCH.	Krupp	1584	·54	0·72	1·21	1·62	1·95	2·32	2·71	....	....	3·39
	do.	1574	·53	0·75	1·24	1·67	1·99	2·44	2·85	....	....	3·38
	do.	1594	·53	0·69	1·18	1·60	1·93	2·29	2·74	....	....	3·39
		Mean	**·533**	**0·72**	**1·21**	**1·63**	**1·96**	**2·35**	**2·77**	....	....	**3·39**
	Farnley	1923	·52	0·62	1·12	1·50	1·95	2·33	2·78	....	....	3·31
	Bowling	1893	·49	0·74	1·28	1·68	2·07	2·50	....	....	....	3·28
	Lowmoor	1863	·50	0·79	1·34	1·77	2·22	2·71	....	....	....	3·35
	Taylor's	1953	·51	0·72	1·23	1·58	1·94	2·33	....	....	....	3·35
	Monkbridge	2013	·51	0·77	1·28	1·67	....	....	....	....	....	2·17
	Cooper & Co.	1983	·53	0·68	1·14	1·55	....	....	....	....	....	1·86
		Mean	**·510**	**0·72**	**1·23**	**1·62**	....	....	....	....	....	**2·88**
FIVE-EIGHT INCH.	Krupp	1604	·65	0·55	1·06	1·41	1·75	2·08	2·32	2·66	3·18	3·50
	do.	1624	·65	0·59	1·10	1·46	1·78	2·15	2·43	2·84	....	3·50
	do.	1614	·66	0·55	1·00	1·39	1·72	2·00	2·25	2·53	....	3·35
		Mean	**·653**	**0·56**	**1·05**	**1·42**	**1·75**	**2·08**	**2·33**	**2·68**	....	**3·45**
	Lowmoor	1873	·63	0·42	0·97	1·31	1·64	1·91	2·21	2·55	3·15	3·30
	Bowling	1903	·62	0·46	0·99	1·35	1·69	1·99	2·25	2·60	3·22	3·28
	Farnley	1933	·64	0·44	0·98	1·33	1·63	1·90	2·18	2·50	3·04	3·19
	Monkbridge	2023	·60	0·44	0·98	1·33	1·68	1·98	2·22	....	....	2·75
	Cooper & Co.	1993	·63	0·40	0·94	1·30	1·64	1·90	....	....	....	2·38
	Taylor's	1963	·63	0·44	0·98	1·34	1·66	....	....	....	....	2·04
		Mean	**·625**	**0·43**	**0·97**	**1·32**	**1·65**	**1·93**	....	....	....	**2.82**

and pressed into aperture ten inches diameter.

99 SOUTHWARK STREET, LONDON, S.E., 17th September, 1875. DAVID KIRKALDY.

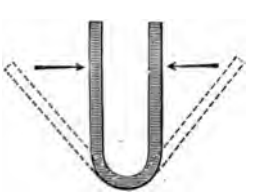
REPORT G.

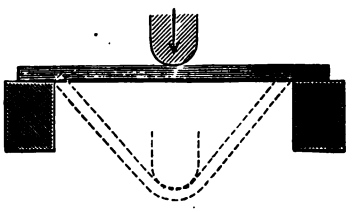
RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO

DISTANCE BETWEEN SUPPORTS—TEN INCHES. NOMINAL THICKNESSES—THREE-EIGHT,

TESTED COLD.

LENGTHWAY.						CROSSWAY.					
id.	Test No.	Thick-ness.	Stress.	Angle.	EFFECTS.	Brand.	Test No.	Thick-ness.	Stress.	Angle.	EFFECTS.
	J	inch.	lbs.	degrees.			J	inch.	lbs.	degrees.	
pp	1557	·46	2859	180	Uncracked.	Krupp	1558	·46	2612	180	Cracked very slightly.
.	1567	·45	2446	180	do.	do.	1568	·45	2434	180	do. do.
.	1547	·44	2353	180	do.	do.	1548	·44	2289	180	Cracked.
	Mean	**·450**	**2553**	**180**			Mean	**·450**	**2445**	**180**	
ıoor	1856	·37	1281	180	Uncracked.	Lowmoor	1857	·38	1367	180	Uncracked.
ing	1886	·40	1632	180	Cracked slightly.	Bowling	1887	·40	1814	180	Cracked.
ɔr's	1946	·39	1592	180	do. do.	Farnley	1917	·40	1792	180	do.
ridge	2006	·37	1381	180	do. do.	Cooper & Co.	1977	·38	1609	152	do.
ley	1916	·41	1619	180	Cracked.	Taylor's	1947	·39	1758	100	do.
& Co.	1976	·38	1809	180	do.	Monkbridge	2007	·37	1531	93	do.
	Mean	**·386**	**1552**	**180**			Mean	**·386**	**1645**	**147**	
pp	1587	·55	3329	180	Uncracked.	Krupp	1578	·53	3003	180	Uncracked.
.	1577	·53	3221	180	do.	do.	1588	·54	3059	180	Cracked slightly.
.	1597	·53	3082	180	do.	do.	1598	·54	3022	180	Cracked.
	Mean	**·536**	**3211**	**180**			Mean	**·536**	**3061**	**180**	
ing	1896.	·49	2012	180	Cracked slightly.	Farnley	1927	·50	2760	180	Cracked slightly.
ıoor	1866	·48	1814	180	Cracked.	Monkbridge	2017	·51	2456	168	Cracked.
or's	1956	·51	2371	180	do.	Lowmoor	1867	·50	1959	141	do.
ley	1926	·51	2339	170	do.	Bowling	1877	·50	2033	137	do.
& Co.	1986	·53	2554	160	do.	Cooper & Co.	1987	·52	2671	136	do.
ridge	2016	·51	2128	100	do.	Taylor's	1957	·52	2284	100	do.
	Mean	**·505**	**2203**	**161**			Mean	**·508**	**2360**	**143**	
pp	1617	·68	4991	180	Uncracked.	Krupp	1618	·67	4959	180	Uncracked.
.	1607	·65	4694	180	do.	do.	1608	·65	4769	180	do.
.	1627	·65	4468	180	do.	do.	1628	·65	4478	180	do.
	Mean	**·660**	**4718**	**180**			Mean	**·656**	**4735**	**180**	
ing	1906	·63	4105	180	Uncracked.	Lowmoor	1877	·64	4436	180	Uncracked.
& Co.	1996	·63	4154	180	Cracked very slightly	Bowling	1907	·64	4480	180	do.
or's	1966	·63	4539	171	Cracked.	Farnley	1937	·63	4389	164	Cracked.
ley	1936	·65	5432	166	do.	Taylor's	1967	·62	4292	117	do.
noor	1876	·63	4304	158	do.	Cooper & Co.	1997	·63	4574	100	do.
ridge	2026	·60	3955	50	do.	Monkbridge	2027	·61	3516	59	do.
	Mean	**·628**	**4415**	**151**			Mean	**·628**	**4281**	**133**	





D. KRUPP, ESQ.,

ESSEN WORKS, RHENISH PRUSSIA ;

2 CROWN BUILDINGS, QUEEN VICTORIA STREET, LONDON, E.C.

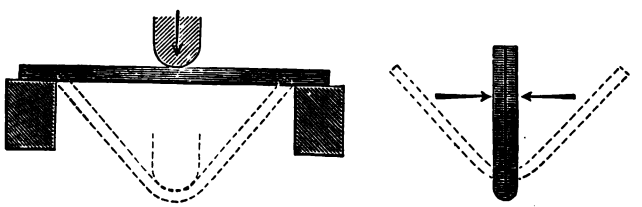
REPORT G.

BENDING STRESS OF TWENTY-SEVEN WROUGHT-IRON PLATES

HALF, AND FIVE-EIGHT INCH. DISTANCE BETWEEN SUPPORTS—TEN INCHES.

TESTED HOT.

NOMINAL THICKNESS.	LENGTHWAY.						CROSSWA			
	Brand.	Test No.	Thickness.	Stress.	Angle.	EFFECTS.	Brand.	Test No.	Thickness.	Stress.
		J	inch.	lbs.	degrees.			J	inch.	lbs.
THREE-EIGHT INCH.	Krupp	1565	·45	580	180	Uncracked.	Krupp	1566	·45	695
	do.	1555	·46	525	180	do.	do.	1556	·46	560
	do.	1545	·44	490	180	do.	do.	1546	·44	560
		Mean	**·450**	**532**	**180**			Mean	**·450**	**605**
	Lowmoor	1854	·37	350	180	Uncracked.	Lowmoor	1855	·38	520
	Bowling	1884	·40	565	180	do.	Farnley	1915	·40	535
	Farnley	1914	·41	555	180	do.	Taylor's	1945	·39	510
	Taylor's	1944	·39	450	180	do.	Bowling	1885	·40	554
	Monkbridge	2004	·37	410	180	do.	Cooper & Co.	1975	·38	550
	Cooper & Co.	1974	·38	430	180	Cracked slightly.	Monkbridge	2005	·37	501
		Mean	**·386**	**460**	**180**			Mean	**·386**	**528**
HALF-INCH.	Krupp	1575	·53	820	180	Uncracked.	Krupp	1576	·53	740
	do.	1595	·53	710	180	do.	do.	1596	·54	663
	do.	1585	·55	695	180	do.	do.	1586	·54	615
		Mean	**·536**	**742**	**180**			Mean	**·536**	**672**
	Lowmoor	1864	·48	550	180	Uncracked.	Lowmoor	1865	·50	580
	Bowling	1894	·49	755	180	do.	Farnley	1925	·50	682
	Taylor's	1954	·51	633	180	do.	Monkbridge	2015	·51	520
	Monkbridge	2014	·51	781	180	Cracked very slightly.	Taylor's	1955	·52	590
	Cooper & Co.	1984	·53	608	180	Cracked slightly.	Bowling	1895	·50	740
	Farnley	1924	·51	600	180	Cracked.	Cooper & Co.	1985	·52	620
		Mean	**·505**	**654**	**180**			Mean	**·508**	**622**
FIVE-EIGHT INCH.	Krupp	1615	·68	1080	180	Uncracked.	Krupp	1616	·67	1030
	do.	1605	·65	1065	180	do.	do.	1606	·65	1030
	do.	1626	·65	1003	180	do.	do.	1626	·65	1000
		Mean	**·660**	**1049**	**180**			Mean	**·656**	**1020**
	Lowmoor	1874	·63	735	180	Uncracked.	Lowmoor	1875	·64	887
	Farnley	1934	·65	970	180	do.	Bowling	1905	·64	885
	Cooper & Co.	1994	·63	680	180	do.	Cooper & Co.	1995	·63	910
	Bowling	1904	·63	735	180	Cracked very slightly.	Farnley	1935	·63	895
	Taylor's	1964	·63	670	180	Cracked.	Taylor's	1965	·62	770
	Monkbridge	2024	·60	685	180	Cracked very badly.	Monkbridge	2025	·61	624
		Mean	**·628**	**746**	**180**			Mean	**·628**	**828**



All planed exactly 2·5 inches wide.

99 SOUTHWARK STREET, LONDON, S.E., 17th September, 1875. DAVID KIRKALD